Delta smelt, VAMP, and exports in the spring of 2005
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This paper references the accompanying slide presentation that I made to the Ops Group on April 14. Some participants were not able to stay for this presentation, some were absent, and those who stayed deserve a more thorough written explanation of my remarks.

Summary

- The delta smelt fall midwater trawl index of sub-adult abundance reached an all time low last year of 74.
- The cause of this low index was an extremely low level of prey (the zooplankton, *Pseudodiaptomus forbesi*), in the lower Sacramento River and nearby areas.
- No data or analyses have shown population effects of entrainment at the export pumps, although the possibility that entrainment is significant in some years in the past cannot be ruled out.
- Based on two separate analyses, one of this year's adult spawning distribution and recent Particle Tracking Model runs and the other of the relationships developed from the past ten years of data. The first analysis showed that none of the export rates considered in this year's Particle Tracking Model runs would have any significant effect on the population of delta smelt. The second analysis, based on past years' data, indicates that at an export rate of at least 5,000 cfs

through May would not be inconsistent with subsequent high juvenile or sub-adult abundance.

- If something must be done in view of last year's low abundance index, attention should be directed at the two power plants at Antioch and Pittsburg that divert large amounts of water from the areas where smelt have spawned and where larvae and juveniles would be expected in greatest abundance. In addition, there should be immediate investigations on the causes of the low densities of Pseudodiaptomus.
- So far, the VAMP experiments and data from before VAMP show no relationship between smolt survival in the Delta portion of the San Joaquin River and export rate.
- Survival in the Delta portion of the San Joaquin River has only been about 15% during VAMP and was even lower last year.
- Clearly, factors other than exports and river flow (which is augmented each year with purchased water) are killing large numbers of salmon in this part of the San Joaquin River.
- A higher export rate during VAMP could provide a useful data point. A low export rate will not.
- Because of the extremely low smolt survival inn the Delta portion of the San Joaquin River, it is possible that salvage of the maximum number of smolts at the Tracy Pumping Plant (i.e., maximum exports at Tracy) and subsequent trucking of those salvaged fish downstream will result in improved survival for this year's outmigrants. This possibility deserves serious consideration.

General conclusions

My colleagues and I analyzed data collected by state and federal agencies concerning delta smelt and San Joaquin salmon smolt survival. Our results strongly suggest that we have been spending too much time, money, and other resources focused on the effects of exports on these fish when, in fact, other factors appear to be having more influence on their abundance.

This focus on exports resulted in the expenditure of 100s of millions of dollars with little or no effect on these fish. It has also diverted attention from the effects of more important factors and figuring out what to do about them. In other words, the attempts to protect these fish by focusing on exports has not only been bad for exports (and all the EWA, b2, water transfers, etc. associated with reduced exports), it has been disastrous for fish.

If delta smelt are in trouble, it is more likely to be the result of food limitation than exports. At least that is what the data say. As for San Joaquin River salmon, if we don't figure out soon what is killing more than 85% of the outmigrants in the Delta portion of the San Joaquin River (and it is not exports), these fish will remain in trouble.

Specific conclusions about delta smelt and the VAMP program

The primary index of delta smelt abundance, the fall midwater trawl (FMWT) index of sub-adult abundance, reached an all time low of 74 last year. No one had been able to identify the factors controlling that abundance. However, keying on data presented by Dr. Bill Bennett, we determined that the FMWT index is primarily determined by the co-occurrence of smelt and prey (the zooplankton, *Pseudodiaptomus forbesi)* in July in the lower Sacramento River and, in some years, nearby areas (slides 5 and 6).

The density of Pseudodiaptomus has shown a marked and persistent decline over the years since its introduction in 1986 (slides 9 and 10) and is approaching densities too low to support delta smelt (zero last year). If delta smelt cannot find other prey, they could go extinct.

However, delta smelt have shown resilience with respect to their primary prey. Prior to the introduction of Pseudodiaptomus, the primary prey for delta smelt was another zooplankton, *Eurytemora affinis*. Eurytemora abundance has declined markedly since introduction of the Asian clam (and, incidentally, Pseudodiaptomus) in 1986. According to Jim Orsi (Fall 2000 IEP Newsletter), Eurytemora may have been an alien species. If so, delta smelt might have twice changed their primary prey, from whatever it was before Eurytemora arrived to Eurytemora and then from Eurytemora to Pseudodiaptomus. They may have to do this again.

I found no relationship between Pseudodiaptomus density in the lower Sacramento River and river flow, which might have established a relationship between water project operations and Pseudodiaptomus density. Nor have we (or anyone else for that matter) been able to find a relationship between either adult or juvenile entrainment and any subsequent index of abundance.

The same unfortunate pattern is seen for San Joaquin River smolts. Each year exports are curtailed by hundreds of thousands of acre-feet for the VAMP "protective experiment." River flows are increased, a barrier is constructed at the head of Old River, and an experiment is run to detect the effect of these factors on smolt survival. The resulting data have shown no effect of exports on survival. More importantly, these results show that 85% of the smolts are dying under these good conditions from causes that have received little or no attention. Last year's mortality was even higher.

As for the question of this year's export rate before, during, and after VAMP, I conclude that an export rate of 5,000 cfs, mostly at the Tracy Pumping Plant, would not have measurable effects on smelt population, would produce a useful data point for the VAMP experiment, and may actually increase smolt survival relative to lower export rates.

As for the longer-term questions, some answer must be found immediately for the decline in late summer Pseudodiaptomus densities in and near the lower Sacramento River. The preservation of delta smelt may depend on that. Some answer must also be found to the question of what is killing 85% or more of the San Joaquin smolts in the Delta portion of the San Joaquin River. It is not exports.

Background: What controls the fall midwater trawl index of abundance of sub-adult delta smelt?

I began with some background on delta smelt. As you know, the "official" index of delta smelt abundance, the fall midwater trawl (FMWT) index of abundance of sub-adult smelt, has been something of a mystery. It is not correlated with the summer townet (STN) index of juveniles that occurs immediately before it. This means that it cannot be correlated with any measure of entrainment of juveniles or adult smelt because that entrainment would occur before and, therefore, affect, the STN index.

Dr. Bill Bennett has presented data showing that food limitation in the late summer and, possibly toxic contamination, has a marked affect on smelt abundance and could, therefore, be controlling the FMWT index.

Based on Bill's analysis, I compared smelt abundance and prey density in ten areas of smelt habitat (slide 4). I used smelt data from the summer townet survey and zooplankton data from Lee Mecum's monthly surveys. According to Bill's Draft Delta Smelt White paper, smelt primarily prey on two zooplankton, Eurytemora and Pseudodiaptomus. Eurytemora abundance was significantly affected by the Asian clam that arrived in 1986. Fortunately for smelt, Pseudodiaptomus was also introduced in 1986 and is now the primary prey of smelt in the summer.

Slide 5 shows the resultant highly significant correlation between the FMWT and the sum over areas of the each area's product of smelt abundance and Pseudodiaptomus density plus the product of smelt abundance and Eurytemora abundance (which was in all cases zero or small).

Slide 6 shows the products for each of the ten areas by year. From this graph we can see that sub-adult smelt abundance in the fall (FMWT index) depends largely on the co-occurrence of smelt and prey in the lower Sacramento River (confluence to just upstream of Threemile Slough) and in some years, nearby areas in July. In other words, if you want a high FMWT index, you must have high abundance of smelt and high density of Pseudodiaptomus in July in the lower Sacramento River or nearby areas.

If export entrainment is affecting the FMWT, it must be affecting smelt abundance and/or Pseudodiaptomus density in these co-occurrence areas in July. One way that exports could be affecting smelt abundance is by entraining smelt that would otherwise have ended up in or near the lower Sacramento River in July. On the other hand, if smelt that were destined to appear in the lower Sacramento River in July were never in areas from which significant entrainment could occur, then exports could not be affecting the FMWT by entraining smelt.

Of course, it is possible that exports could be affecting the FMWT in some other way. Slide 9 shows two graphs concerning variation of Pseudodiaptomus density in the lower Sacramento River in July. The upper graph plots Pseudodiaptomus density against river flow at Rio Vista from Dayflow data. Exports could be affecting river flow there as a result of reservoir releases made to support exports. However, no effect can be seen.

The lower graph is disturbing. It shows the variation in Pseudodiaptomus with time for the last 20 years. Clearly, there is a marked downward trend, with last year's data point at zero. As shown on slide 10, the same decidedly downward trend is found for the lower San Joaquin River and Chipps Island areas, the two other areas of past high smelt-prey co-occurrence. Maybe delta smelt will find another primary source of food. If they do not, these data suggest the possibility of extinction of smelt soon due to lack of food in and near the lower Sacramento River in July.

Slide 11 shows the abundance of smelt in the lower Sacramento River, the lower San Joaquin River, and the Chipps Island area. No long-term downward trend has occurred. However, there has been a marked decline in delta smelt abundance in the primary area of co-occurrence, the lower Sacramento River, since 2001. There is no correlation between smelt abundance and Pseudodiaptomus density in the lower Sacramento River or nearby areas.

The key questions raised by these results are shown on slide 8. They are:

- Where do smelt in the high co-occurrence areas in the late summer come from? Is there an effect of exports?
- What factors affect prey (Pseudodiaptomus) density in the areas of high co-occurrence in the later summer?

My recommendations for the next steps are shown on slide 14. Please pay particular attention to the first of these, which was not reflected in the otherwise excellent minutes of last Wednesday's meeting of the Delta Smelt Work Group. One of Bennett's graduate students, Jim Hobbs, presented a paper at the last CalFed Science Conference. He described a method of analyzing the isotopic composition of delta smelt otoliths to identify the location from which the smelt originated. I understand that smelt from areas of high co-occurrence from past years have been preserved. In fact, some have already been prepared for analysis by Jim, so much of the preparation cost has already been taken care of. The analyses would not be expensive, probably in the range of $20,000. I think we should figure out a way to raise that money and have these analyses done. The results should go a long way toward answering the question of whether and when entrainment makes a difference.

Given the trends in Pseudodiaptomus densities mentioned above, the highest priority should be to identify the causes of the downward trend in Pseudodiaptomus shown in slides 9 and 10.

One other possibility deserves some attention. Two large power plants at Antioch and Pittsburg divert water at rates sometimes comparable to the state and federal export facilities. These power plants are much closer to the critical areas of July smelt-prey co-occurrence than the export pumps. As far as I know, there has been no evaluation of the effect of power plant entrainment on delta smelt.

We are also continuing to work on questions of smelt-food co-occurrence and smelt movement before and after July. We hope to figure out what factors affect the 1/3 of the variation in the FMWT index not explained by the July co-occurrence products. Also, we would like to be able to relate July co-occurrence back to the period when entrainment is occurring.

This year's smelt distribution and particle tracking model results

Slide 16 is presented as a reminder that we are dealing with a species that last year hit a record low level of relative abundance as measured by the FMWT index. It seems clear from the Pseudodiaptomus trends presented above that food limitation is a primary cause of low abundance of sub-adult smelt in recent years. The low density of Pseudodiaptomus in recent years is, by itself, enough to explain the low abundance of delta smelt.

Slide 18 shows the results to date of the spring Kodiak trawls for adult delta smelt. The three charts on slide 18 show female delta smelt. These charts show that smelt are spawning in the lower Sacramento River, and areas immediately upstream and downstream of there. Smelt eggs are distributed over and attach to substrate, such as rocks, near where smelt spawn. Eggs hatch in about two weeks into 5 or 6 mm larvae that are thought to behave as neutrally buoyant particles. Therefore, results from the Particle Tracking Model, that simulates the movement of neutrally buoyant particles, should represent the movement of larval smelt.

Slides 20, 21, and 22 show Kodiak trawls from past years. From these charts we can see that spawning smelt are unlikely to be found upstream of locations where smelt were found in early surveys. This is more likely to be true this year with high flows on the San Joaquin River. Therefore, it is reasonable to assume that this year, smelt will spawn no nearer the export pumps than Twitchell Island.

Slides 25, 26, and 27 show the most recent Particle Tracking Model results. The starting ("injection" in PTM jargon) point for particles is shown in the title of each graph. Each graph shows the chances of being entrained from that starting point (y axis) given how many days have passed since the start of the run (x axis). These graphs show that the chances of being entrained in 35 days are about 60 to 70% for particles starting from Turner Cut or Holland Tract. They are less than 10% for particles that start at Twitchell Island and essentially zero for particles starting at Rio Vista or Chache Slough.

Note that the % of the population entrained is the product of the chance of being entrained from any location (say, Twitchell Island) and the fraction of the total population that is near that location. From the Kodiak trawl data and the PTM results, we can see that there is essentially no chance that entrainment will affect the smelt population this year.

The 20 mm surveys have also started, and the second of these shows smelt in the southeastern Delta, near the export pumps. However, only a few smelt have been caught in the 20 mm survey, and the 20 mm surveys are notoriously inefficient at catching larval delta smelt, whereas the Kodiak trawls for adults are much more efficient. If both the Kodiak data for spawning adults and the 20 mm data are correct, then either of two possibilities must be true:

- So few adults spawned in the southeast Delta that they did not show up in the Kodiak trawls, but their relatively few progeny have for some reason been caught in the southeast Delta but not elsewhere in the second 20 mm survey.

- Smelt spawned far from the southeast Delta and somehow most of the larvae moved about 20 miles, much of it upstream, to the southeast Delta.

In any disagreement involving Kodiak data on adults and 20 mm data on larvae, the much greater efficiency of the Kodiak trawls must be given preference. Therefore, based on data collected to date, there is no reason to believe that any significant fraction of the smelt population is close enough to the export pumps to be entrained.

Application of past years' data to this years' situation

I used data from 20 mm surveys for 1995 through 2004 to estimate the fraction of hatched delta smelt at each 20 mm sampling station for each survey. Un-hatched smelt, i.e., eggs or "un-spawned" smelt, cannot be sampled or entrained (the eggs are attached, not free-floating). I then used data from Particle Tracking model runs to estimate the fraction of hatched smelt entrained.

I based estimates of fraction hatched on information in Bennett's draft white paper, Bennett's estimates of spawning dates from otolith backdating for two years, and the Mager, et. al. article, I estimated the fraction of smelt hatched assuming that hatching began two weeks before average Delta-wide temperature reached 15 degrees C and proceeded in a straight-line fashion until 20 degrees C. Note that Kelly Souza reports (IEP

Newsletter, Summer, 2004) that spawning occurred at about 12 degrees C when comparing spent females and the temperature of water where the females were. This is not necessarily inconsistent with my assumption that is based on comparison of fraction hatched and average Delta-wide temperature.

From those calculations, I obtained estimates of percentage of larval-juvenile population entrained, shown in slide 31. The three columns represent different ways of weighting or not weighting the catch per unit effort data from the 20 mm surveys. All three methods give essentially the same results, so I will just refer to the un-weighted values (first column) from here on.

The question about these estimates is, “So what?” Is there any relationship between the percentage of larval-juvenile entrainment and subsequent abundance of juvenile or sub-adult delta smelt? The graphs on slides 33 and 34 appear to indicate that the answer is “No.” However, these graphs are comparing abundance with percentage entrained, so we might not expect a relationship. We have tried numerous other analyses, including comparison of the residuals of STN vs. previous FMWT with percentage juvenile entrainment. We also compared the ratio of STN to previous FMWT with percentage juvenile entrainment. We have not been able to find a relationship between STN and juvenile entrainment. Of course, there is no relationship between FMWT and previous STN, so the search for a relationship between percentage entrainment and subsequent FMWT is bound to be fruitless, as the graphs on slide 34 suggest.

Because delta smelt is a listed species, we cannot expect that unlimited entrainment would be permitted. Some rational method is necessary as a basis for curtailing exports. We note from the graphs on slides 33 and 34 that, for the ten years of data we have, if juvenile entrainment is below about 20%, subsequent high STN and FMWT abundance indices have occurred in the past. Such high indices are not guaranteed. Subsequent low indices cannot be ruled out. Therefore, pending further analyses, it would be reasonable to use 20 % or less as a target for each year.

Obviously, if all juveniles were entrained, there would be no juveniles or sub-adults, so we cannot conclude from these graphs that entrainment can never have an effect on subsequent abundance. Recalling the co-occurrence analysis, it is also possible that, in some years, a significant percentage of smelt that would have co-occurred with prey in the lower Sacramento River and nearby areas in July were entrained. In that case, entrainment would have affected the subsequent FMWT index. If this occurred only in some years, that would explain the lack of correlation between the FMWT and the percentage entrained for all years.

More work is needed on the effects of entrainment on subsequent abundance. For now, we have no relationships indicating that entrainment is important. We do know that co-occurrence of Pseudodiaptomus and smelt in July is very important. We believe that is the place to start the search for the significance of entrainment. If we can figure out if and when entrainment affects the late summer co-occurrence of smelt and prey, we might have a rational basis for managing entrainment, if, in fact, it turns out that such management makes a difference.

For now, we might expect that the higher the percentage of smelt in the southeast Delta and the higher the export pumping rate, the higher the percentage of the population entrained. This turns out to be the case. Further, we might expect that the percentage of smelt in the southeast Delta would depend on Delta outflow in the spring. This also turns out to be the case.

Slide 36 shows the relationship between the fraction of the total larval/juvenile population in the southeast Delta in 20 mm surveys 2 through 4, the surveys for which a significant percentage was typically in the southeast Delta in the last ten years, and the average Delta outflow from mid-March to mid-April.

Slide 37 shows the annual percentage of juveniles (larvae and juveniles) entrained vs. the product of the % in the southeast Delta and the average export rate in the first five surveys.

If we know or can predict the mid-March to mid-April outflow we can predict the percentage in the southeast Delta. If we have a target percentage entrainment, we can use the graphs on slide 37 to estimate a target export rate for the first five surveys. Slide 39 shows the target export rates based on this year's conditions, depending on the choice of the target percentage entrainment. Note that we have not been able to find a relationship between this target percentage entrainment and subsequent abundance.

Recall that so long as the percentage entrainment was less than about 20% in the past, subsequent high juvenile and sub-adult abundance could occur. Therefore, a conservative target for percentage entrainment might be 10%, which gives a target export rate for the first five surveys (say, April and May) of 5,000 cfs.

Note that because this year's flows on the San Joaquin River are higher than in past years, relative to Delta outflow, the estimate of percentage smelt in the southeast Delta from slide 36 is probably high. Therefore, the target export rate of 5,000 cfs is also environmentally conservative, given the conservative target percentage entrainment of 10% rather than 20%.

San Joaquin River salmon smolt survival and VAMP exports

The Vernalis Adaptive Management Plan is supposed to be an experiment to assess the effect of river flow, export rate, and barrier operation at the head of Old River on survival of smolts migrating from the San Joaquin River system. It is also a "protective experiment," intended to protect the smolts.

Because of high flows on the San Joaquin River this year, the VAMP experiment cannot be conducted. Instead, a different experiment is possible. The agreement describing VAMP suggests that exports in a year such as this be 1,500 or 3,000 cfs during the period of the experiment, although they could be higher. This year's period will likely be the month of May.

Obviously, any experiment designed to test the effects of export rate on smolt survival should allow for higher export rates. Otherwise, an export effect may exist but not be detected because export rates were never high enough to produce measurable, statistically significant effects.

However, two concerns have prevented conduct of experiments with higher export rates. One is the belief that exports were important to smolt survival. In other words, even though one purpose of VAMP is to test the effect of exports on smolt survival, this test is being conducted with the firm belief that the results are already known, namely, that, contrary to experimental results to date, higher exports result in lower smolt survival.

The second concern arises from the possibility that higher exports could result in more entrainment of delta smelt. When the San Joaquin River Agreement, of which VAMP is a key part, was being negotiated, the USFWS took the position that if exports were allowed to be above those eventually included in the VAMP protocol, no agreement would be possible because of concerns about delta smelt. Therefore, the VAMP protocol called for minimum practical exports of 1,500 cfs in most years, allowing for 3,000 cfs in higher flow years. The same export levels were suggested in cases, such as this year's, where river flows are too high to allow for a VAMP experiment.

The delta smelt discussion above addressed that concern and concluded that, based on this years distribution of spawning adults and Particle Tracking Model runs, none of the export rates analyzed would affect delta smelt populations. Analyses based on data from the past ten years applied to this years circumstances indicated that exports as high as or higher than 5,000 cfs would not be inconsistent with subsequent high abundance of delta smelt.

Results from previous years of VAMP and from selected years prior to that indicate the following:

- Survival of smolts passing down the San Joaquin River is now very low, about 15%. It was even lower in 2004. The 85+% mortality of smolts is occurring with augmented river flow, highly curtailed exports, and a barrier at the head of Old River. Clearly, some heretofore-unexamined factor(s) is having the primary effect on smolt survival.
- There is a correlation between smolt survival and river flow, although there may be questions about the management relevance of that correlation.
- Installation of a barrier at the head of Old River seems to improve survival, but no tests have been carried out in recent years to compare the survival of smolts entering Old River with the survival of those passing down the San Joaquin River. If the survival of smolts entering Old River is not less than 15%, then, for reasons described below, it is likely that the Old River route could provide higher survival.

- No correlation has been found between export rate and smolt survival. There are two possible reasons for this:
    - There is no relationship between export rate and smolt survival with a barrier at the head of Old River.
    - There is a relationship, but it cannot be detected because export rates are never allowed to be high enough to produce measurable effects.

The VAMP experimental protocol and, in fact, underlying objectives of the State Water Resources Control Board and the Delta Smelt Biological Opinion make use of the ratio of river flow to exports to limit exports. Use of this ratio is misleading given the results of the VAMP experiments to date. If there is a correlation between river flow and survival and not between exports and survival, then we might expect, and, in fact, find, a relationship between the ratio (river flow to exports) and survival. This does not mean, as some have concluded, that exports are important to survival.

So far, the data indicate that survival varies randomly with export rate. If any variable that is random with respect to smolt survival (Dow Jones average during VAMP, number of vehicle accidents in California during VAMP, etc.) is divided into river flow (which is not random with respect to smolt survival), there is a reasonably good chance that the resulting ratio will show a correlation with survival. No one would conclude from such an analysis that stock averages or traffic accidents were affecting smolt survival, but that is exactly what is being done in this case with exports.

There is no reason to confound the effects or non-effects of exports on survival with the effects of river flow on survival. Statistical methods are available to analyze the two effects separately (and when such methods are applied to these data, no export effect has been found). Combining the effects of river flow and exports by taking the ratio of the two is unnecessary and misleading.

Therefore, any argument for lower exports that rests on the need to obtain a data point at a higher ratio of river flow to exports is baseless.

From an experimental standpoint an experiment with higher exports would be desirable. If this year's experiment is, once again, conducted with exports at low exports of 1,500 cfs, one of three general results will be observed:

- Smolt survival will be about what was expected give the higher river flow, in which case the already reasonably good relationship between survival and river flow will be confirmed.
- Smolt survival will be higher than expected from river flow, in which case we might conclude that uncontrolled river flows are good for smolt survival (and that we should pray for rain each year).
- Smolt survival will be lower than expected for river flow, in which case we might conclude that whatever is killing 85% of the smolts has become even more of a problem or that not having a barrier at the head of Old River is good for survival.

We will still have no additional information about the effect of exports on smolt survival.

If, on the other hand, we have an experiment with higher exports, the same outcomes described above will allow us to infer that exports are or are not likely to be important.

As for the "protective" aspect of the VAMP "protective experiment," we should be very concerned about the fact that so few (15% or so, even less last year) of smolts have been surviving passage down the Delta portion of the San Joaquin River with augmented river flows, very low exports, and a barrier at the head of Old River. Something is obviously wrong in the Delta portion of the San Joaquin River.

According to Brandes, studies done from 1985 to 1991 showed that smolts released into Old River had lower survival than those released into the San Joaquin River downstream of Old River. However, it is not clear that survival in the San Joaquin River was at the low levels we have observed in the last few years.

According to the standard assumptions set forth on slide 46 for estimating the loss of salmon at the export pumps, survival for smolts entrained at the Tracy Pumping Plant would be in the range of 30%. Relative to the distance from the head of Old River to Chipps Island, the distance from the head of Old River to the Tracy Pumping Plant is not great. Therefore, if the survival from the head of Old River to Chipps Island is not markedly worse than the survival down the San Joaquin River, smolts entering Old River and subsequently salvaged at Tracy and trucked downstream would have a higher survival than those passing down the San Joaquin River.

This would not be the case for smolts salvaged at the Banks Pumping plant because of the high predation loss (75+%) in Clifton Court Forebay.

Based on this analysis, it is not unreasonable to conclude that, given the current poor survival of smolts in the San Joaquin River, the best way to get smolts from Vernalis to Chipps Island this year, without a barrier at the head of Old River, may be to have maximum pumping rates at Tracy and minimum at Banks in hopes of salvaging as many smolts as possible at Tracy. Someone should review past release-recapture experiments to confirm this before ruling out the possibility of higher export rates before, during, and after the VAMP period. Perhaps extraordinary measures are necessary to deal with extraordinarily low survivals in the Delta portion of the San Joaquin River.

I do not mean to imply by that all water exported at Tracy should go to federal contractors, only that, this year, it might be good for San Joaquin salmon to salvage as many of those fish as possible at the Tracy Pumping Plant.